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ORIGINAL ARTICLE

# Correction of Class 2 malocclusion by means of a fully adjustable, virtually unbreakable, mandibular positioning (jumping) device

## Zastosowanie indywidualnie nastawianego, wytrzymałego aparatu skokowego do korekty położenia żuchwy pacjentów z wadą klasy II

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*Abstract*

***Introduction.*** *The construction and adaptation of the appliance to the individual patient is described and illustrated.* ***The aim*** *of the present report is to describe the development and clinical testing of an adjustable, unbreakable "bite-jumping" device, the "Flex Developer"® incorporating a nylon rod as the extendable "bite-jumping" element.* ***Material and method.*** *The report describes clinical testing on two groups of patients (young N = 17, mature N = 12) using a cephalometric appraisal before and after treatment.* ***Results.*** *The efficiency of the appliance in correcting Class II malocclusion by means a series of skeletal and dento-alveolar changes is clearly illustrated, the statistically significant skeletal improvement being greater in the younger (under 19 years) patients.* ***Conclusion.*** *The appliance constitutes a reliable adjunct to orthodontic correction of the Class II anomaly.*

*Streszczenie*

***Wprowadzenie.*** *Przedstawiono konstrukcję i możliwości indywidualnego dostosowania zastosowanego aparatu skokowego.* ***Celem publikacji*** *jest przedstawienie wyników klinicznego zastosowania indywidualnie nastawianego, wytrzymałego aparatu skokowego „Flex Developer" w którym jako element aktywny zastosowano nylonowy trzon.* ***Materiał i metoda.*** *Raport opisuje zastosowanie aparatu skokowego w dwu grupach badawczych (u 17 pacjentów dorastających i u 12 pacjentów dorosłych). Do oceny wykorzystano analizę cefalometryczną przeprowadzoną przed i po leczeniu.* ***Wyniki.*** *Zmiany szkieletowe oraz zębowo-wyrostkowe jednoznacznie potwierdzają skuteczność zastosowanego aparatu skokowego. Obserwowane zmiany były znamiennie statystycznie większe w grupie młodszych pacjentów (poniżej 19 roku życia).* ***Wniosek.*** *Zastosowany aparat skokowy stanowi wiarygodną pomoc w ortodontycznym leczeniu wad okluzji klasy II.*

**KEYWORDS:**
jumping device, Class II malocclusion, Flex developer

**HASŁA INDEKSOWE:**
aparat skokowy, wada klasy II, Flex Developer

## Introduction

The concept of correction of Class II malocclusion by means of a "jumping device" is not new in orthodontics, this type of appliance having been presented for the first time at a Berlin exhibition in 1909 by Emil Herbst and the effect of his appliance being summarized in a later publication in 1934.[1] The use of this form of treatment seems however to have become less frequent in the following years, before a revival of the appliance in the second half of the 20th century, mainly as a result of the extensive researches by

*Pancherz,*[2], *Paulsen*[3] and others, studies which stimulated renewed interest for the principle of "bite jumping".

While the basic principle of "bite jumping" appeared to be efficient in solving the occlusal problems, the complexity of the appliances as well as problems with breakages inspired a search for alternative appliances based on the same therapeutic principles. Correspondingly, over the years many modifications of the appliance have been devised, the aim generally being to reduce the complexity of manufacture and not least the price. The original appliance described by *Herbst* was attached to the teeth by means of cast metal splints, while the new generation of appliances, e.g. those of *Pancherz*[2] consisted of the typical telescope mechanism, mounted on a metal framework (maxillary and mandibular) soldered to orthodontic bands. Later again, as an alternative to the band mounted appliance, a version incorporating acrylic cap splints on the buccal teeth has been suggested[4] thus avoiding expensive and complicated steel construction.

With the advent of the so-called Jasper jumper®[5,6] a new type of "bite jumping" appliance was created, which could be used in connection with a standard edgewise fixed orthodontic appliance, avoiding expensive and time-consuming laboratory work, as well as a certain amount of clinical time. The Jasper Jumper® consists of a relatively stiff, covered spring device of fixed length which guides the mandible ventrally in connection with the closing movement. These appliances have proved to be clinically efficient[7] and well tolerated by the patients, though it is generally agreed that breakage is relatively common and expensive. A further development was that of the Flex developer® an adjustable mandibular advancing appliance to be mounted in connection with a standard fixed orthodontic appliance (Fig. 1).

The advantage of this type of appliance, apart from its clinical efficiency, is that it is fully adjustable and virtually indestructible.

In cases treated with the "flex developer" it is important that the jumping device can glide mesio-distally along an auxiliary arch fitted to the mandibular arch, enabling a sufficient degree of freedom in connection with mandibular movement, in particular with opening and lateral movements.

**The aim of this report** can be divided into three sections, namely:

1. Presentation of the "Flex Developer®" an updated version of a "bite-jumping" appliance, based on a length-adjustable nylon construction, facilitating easy adjustment and high strength.
2. Evaluation of the clinical effect of the "Flex Developer®" appliance investigated in a pilot study on a group of patients with Class II malocclusion. The experimental group was divided into two parts ("young" and "mature") based on an estimation of skeletal maturation and the effect and morphological changes brought by "bite jumping" were investigated by means of a short cephalometric analysis.
3. Demonstration of the effect of Flex Developer® treatment on individual patients by means of a clinical description of treatment of two patients representing the two groups described in the paragraph above.

## *The development of a new "bite jumping" appliance - the Flex Developer®*

Based on experiences gained through use of various types of jumping device, it was decided to construct a new type of appliance, which should fulfil the following criteria:

a) The appliance should be constructed as an adjunct to a standard fixed orthodontic appliance so that necessary arch development and alignment could be performed prior to, and maybe concurrently with sagittal occlusal correction.

b) The appliance should be adjustable such that the necessity of keeping a comprehensive stock of many different sizes, possibly also suited for left and right sided use, could be avoided.

c) The main element of the appliance should be created of a strong, preferably indestructible material. For this purpose nylon was chosen.

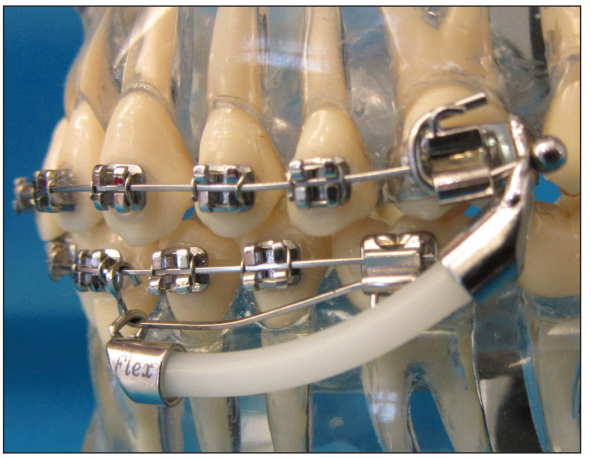

**Fig. 1.** *The Flex Developer® occlusal jumping device appliance in place.*

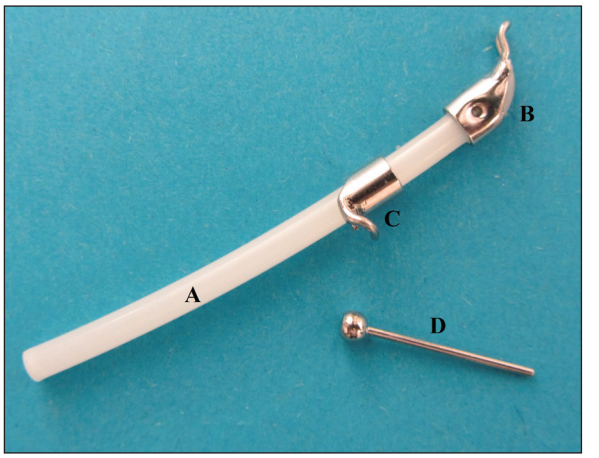


**Fig. 2.** *The Flex Developer® occlusal jumping device appliance.*

The appliance should promote the mesio-distal movement necessary for the correction of the Class II malocclusion, but lateral mandibular excursions should be possible, a problem with the original "Herbst appliance" and probably the major cause of breakages.

The appliance constructed on the basis of the criteria stated above, the Flex Developer® is seen in Fig. 2 and consists of nylon Rod (A), 3.0 mm in diameter, with two metal caps, the superior maxillary cap (B) being fixed to the headgear tube (distal surface) of a band on the maxillary first molar, and the mandibular cap (C) being moveable along the nylon rod making the length of the final appliance adjustable. Notice the small pin with a ball end (D) which is used to anchor the jumping device at the headgear tube on the appropriate molar. This pin will be inserted from the distal side, making the jumper as long as possible and the force direction as horizontal as possible.

## *Placement of the Flex Developer® (Fig. 3-6)*

Fig. 3. Auxiliary wire 0.017"x 0.025".

Fig. 4. The auxiliary wire in place.

Fig. 5. Flex Developer® attached to maxillary molar, ready for length adjustment.

Fig. 6. Finished Flex Developer® in place.

### *Stage one: arch placement*

The dental arches are levelled with a standard type of fixed orthodontic appliance and should be aligned to such a point that the proposed ventral posturing of the mandible can take place without hindrance resulting from retroclined maxillary molars, deep bite or other intra-arch irregularities. The archwire should be of steel and preferably full dimensioned for the bracket system employed, experience showing that a 0.018"x0.025" arch system is adequate.

### *Stage two: the auxiliary wire*

Fig. 3 shows the auxiliary wire system which is used to allow the jumper to slide in connection with the anterior placement of the mandible, thus correcting the Class II discrepancy. This wire is supplied together with the Flex Developer® though can easily be created individually if necessary. Fig. 4 shows the wire in place. The vertical leg of the auxiliary wire should not touch the bracket of the canine, thus avoiding damage to the canine brackets, which is a regular feature if this condition is not observed.

### *Stage three: placement of the flex developer*

The first Flex Developer® is taken and fitted to the appropriate maxillary first molar (distal surface of the headgear tube), passing the soft pin through the tube from the distal side and bending it slightly in order to avoid its falling out. In order to adjust

**Fig. 3.** *Auxiliary wire 0.017″x 0.025″.*

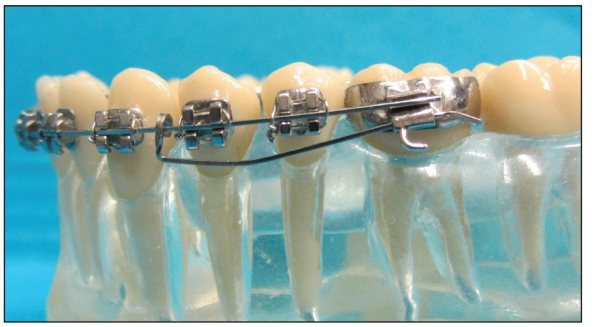

**Fig. 4.** *The auxiliary wire in place.*

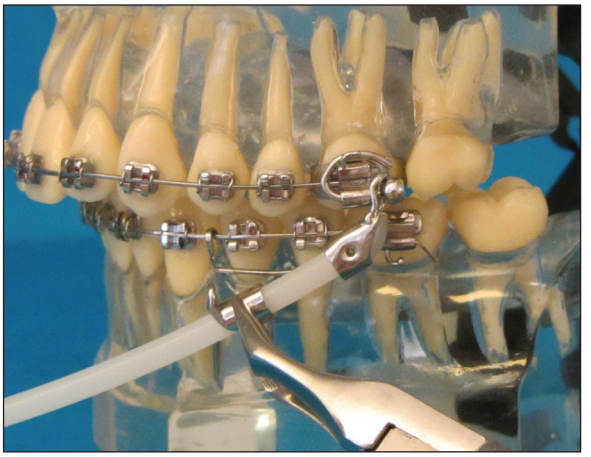

**Fig. 5.** *Flex Developer® attached to maxillary molar, ready for length adjustment.*

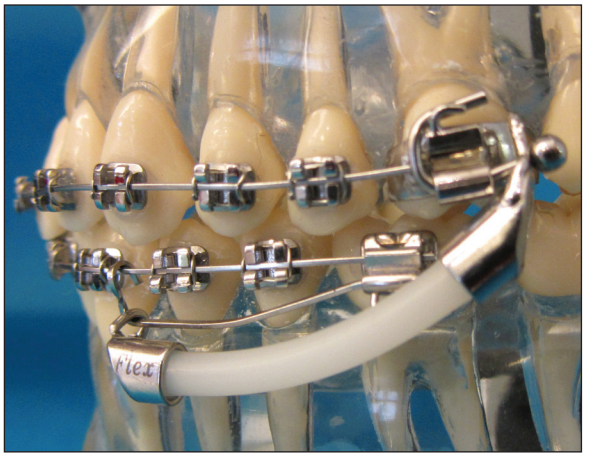

**Fig. 6.** *Finished Flex Developer® in place.*

the length of the jumping device, the patient is now asked to position the mandible forward to the relationship anticipated after the "bite-jumping" procedure though, in general respecting a 4.0 mm anterior movement as maximum. Care should also be taken to observe that the midline is correct in order to avoid an asymmetric effect of the appliance.

Having identified the proposed mandibular position and adjusted the lower sliding stainless steel collar accordingly in the mesio-distal direction, the latter should be rotated onto the nylon rod, so that the small wire element fixed to the steel collar acts as a hook, (Fig. 5) securing the appliance to the main archwire. Having established the correct length of the flex developer the steel collar should be squeezed gently. At this stage the appliance can be removed momentarily, excess length of nylon removed and the ends polished. The Flex Developer® should then be replaced and fixed in position superiorly, by pulling the soft pin through the headgear tube from the distal, bending it for securing and inferiorly by squeezing the clip on the archwire.

The jumping device having been secured attached on both sides (Fig. 6), the patient should be instructed to open and close the mouth as well as to perform reasonable lateral movements, so that the freedom of the jumping device in connection with mandibular movement can be assured.

The patient can now be dismissed, but should be warned that even though the appliance feels very sturdy, it can easily be destroyed by over-zealous masticatory movements and a reasonable degree

**Table 1.** Age and sex distribution of the participants of pilot study

| | sex | N | Min | Max | average | Total average |
|---|---|---|---|---|---|---|
| Young patients | ♀ | 11 | 13 y 3 m | 19 y 0 m | 15 y 4 m | 15 y 0m |
| | ♂ | 6 | 13 y 0 m | 16 y 4 m | 14 y 6 m | |
| Mature patients | ♀ | 9 | 19 y 7 m | 35 y 9m | 26 y 3 m | 27 y 8 m |
| | ♂ | 3 | 19 y 11 m | 43 y 0 m | 32 y 0 m | |
| TOTAL | | 29 | | | | |

of care must therefore be shown. Experience shows that the appliance should be worn over a period of approximately 6 months. If the overbite is very great at the start of treatment (e.g. greater than 6.0 mm) activation of the appliance can take place in stages. In such cases, the soft pin at the maxillary molar is not pulled tightly to the headgear tube initially, but is left somewhat longer and then re-activated approximately 1.0 mm per month.

### *A pilot study of 29 patients intended to investigate the skeletal and dental effect of the Flex Developer® jumping device*

## Material and methods

As a result of the clear advantages afforded to the patient by this type of therapy, it was decided to perform a retrospective comparative cephalometric study in order to demonstrate average changes in the dento-facial and occlusal morphology brought about by the use of the jumping devices. The material for the present study, which should be considered a pilot study, comprised 29 patients exhibiting a Class II skeletal pattern (ANB minimum 4.0º), all of which were treated with a Flex Developer®. The age and sex distribution of the participants is shown in Table 1. As suggested previously, the appliance was used over a six month period for each individual and the average total treatment time with the fixed appliance was under 24 months. Breakages of the "jumping device" occurring during the treatment period would be noted.

Since it is generally accepted that the growth of the jaws ceases at approximately 18 years of age, it was decided to divide the material into two groups, a "young" group of individuals with a maximum

**Table 2.** Age distribution and skeletal maturation (Cvs) of participants in the young patients group

| PATIENT | AGE | Cvs |
|---|---|---|
| T.T. | 13 years 0 months | 3 |
| S.I. | 13 years 3 months | 3 |
| S.V. | 13 years 3 months | 2 |
| H.M. | 13 years 4 months | 3 |
| H.I. | 13 years 11 months | 3 |
| H.O. | 14 years 2 months | 4 |
| O.O. | 14 years 2 months | 4 |
| V.A. | 14 years 2 months | 3 |
| B.B. | 14 years 2 months | 4 |
| V.P. | 15 years 0 months | 5 |
| P.T. | 15 years 1 month | 4 |
| A.V. | 15 years 6 months | 5 |
| B.S. | 16 years 4 months | 5 |
| D.A. | 16 years 11 months | 4 |
| S.H. | 17 years 0 months | 5 |
| T.Y. | 17 years 2 months | 5 |
| S.K. | 19 years 0 months | 5 |

age of 19 years at the start of treatment (N= 17, ♂=11, ♀=6) and a "mature" group from 19 years upwards (N= 12, ♂=9, ♀=3). The correctness of this division was controlled by means of the cervical vertebrae determination of skeletal maturation as described by *Franchi* et al.[8] The results of the determination can be seen in Table 2 and Table 3 describing the status of the patients at the time of the start of treatment ($t_0$).

**Table 3.** Age distribution and skeletal maturation of participants in the mature patients group

| PATIENT | AGE | Cvs |
|---|---|---|
| V.S. | 19 years 7 months | 5 |
| F.R. | 19 years 11 months | 6 |
| M.I. | 20 years 4 months | 6 |
| K.O. | 21 years 9 months | 6 |
| K.M. | 22 years 9 years | 6 |
| L.O. | 26 years 4 months | 6 |
| K.T. | 27 years 8 months | 6 |
| P.L. | 29 years 0 months | 6 |
| K.O. | 32 years 11 months | 6 |
| M.V. | 33 years 1 month | 6 |
| P.S. | 35 years 9 months | 6 |
| Y.V. | 43 year 0 month | 6 |

### *A simplified cephalometric analysis*

For the sake of brevity a simplified form of cephalometric analysis, based on the occlusal plane was created using a series of angular parameters intended to describe the sagittal jaw relationship and the inclination of the maxillary and mandibular incisors (Table 4).

The relative sagittal position of the jaws is expressed by means of the ANB angle and the position of the incisors, described partly as the angular relationship between the long axes of the incisors themselves and to the occlusal plane and partly as the inter-incisal angle. These parameters described and illustrated in Fig. 7 and have been explained in detail in a previous publication.[9]

Prior to the main study, a preliminary methodological study was performed in the form of a double determination of parameters using the cephalometric material of 12 patients, measured twice by one observer (IP), the observations taking place in 3 months intervals. The comparison was made using Dahlberg's formula[10] (Fig. 8) and the so called MME formula described by Houston[11] (Fig. 9) which is devised to minimize the effect of bias in a small material. The results can be seen in Table 4.

In the pilot study and patient cases, cephalometric recordings were made at three stages. Stage ($t_0$) prior to orthodontic treatment, Stage ($t_1$) at the end of arch levelling, prior to the initiation of the "bite jumping" phase and Stage ($t_2$) after the period of "bite jumping" and completion of treatment.

**Table 4.** Cephalometric parameters included in the short cephalometric analysis and the results of the methodological error (double determination) study

| | Mean | Dahlberg (SD) | MME (SM) |
|---|---|---|---|
| SAGITTAL JAW REL. | | | |
| A-n-B | 3.0° | 0.60 | 0.63 |
| INCISAL INCLINATION to OP | | | |
| Maxillary Ils/OP | 60.0° | 1.10 | 1.15 |
| Mandibular Ili/OP | 75.0° | 1.51 | 1.58 |
| Inter-incisal angle | 132.0° | 1.96 | 1.88 |
| INCISAL RELATIONSHIP | | | |
| ii to A-pg | 1.0 mm | 1.76 | 1.83 |

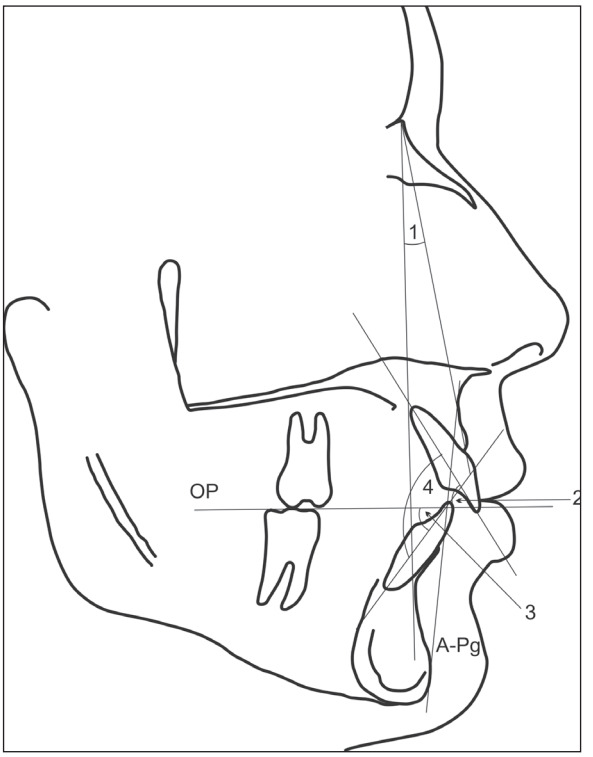


**Fig. 7.** *Cephalometric analysis, 1 = ANB angle, 2 = maxillary incisor inclination to occlusal plane, 3 = mandibular incisal inclination to occlusal plane, 4 = inter-incisal angle.*

$$S_D = \sqrt{\frac{\sum_{i=1}^{n} d_i^2}{2n}}$$

**Fig. 8.** *Dahlberg's formula for comparison.*

$$S_M = \sqrt{\frac{\sum_{i=1}^{n} (d_i - \bar{d})^2}{2(n-1)}}$$

**Fig. 9.** *MME formula by Houston.*

On the basis of the age related division described above, the results of the cephalometric analysis were presented and group means tested by use of a non-paired t-test having been tested for normal distribution and variance homogeneity. The results of the comparison can be seen in Table 5 ("young" patients) and Table 6 ("mature" patients). It will be noticed that comparison is made over three periods namely the "levelling" phase ($t_0$-$t_1$,), the "jumping and completion phase" ($t_1$ to $t_2$) and the "total treatment times ($t_0$ to $t_2$).

## Results

Judged clinically it can be stated that the aims of the "bite-jumping" treatment, has been achieved within the normal treatment time in all cases. Success of treatment was defined as the achievement of normal molar relationship and establishment of good incisal contact and was achieved in all cases. No breakage of the jumping devices during the study was registered. Considering the cephalometric changes, a certain amount of variability was of course noticed.

The determination of the skeletal maturation based on the Cvs method demonstrated a small amount of variation for the patients in the younger group with the majority being in either stage 4 or 5 (significant growth[4] or slowing down[5]). Five of the younger patients demonstrated stage 3. In the mature group, all but one patient exhibited stage 6. The results support therefore the division of the patient material into two groups, based on age/maturity.

The results of the reproducibility study can be seen in Table 4 expressed as the Dahlberg coefficient "method of moments" variants estimator. While the variants of the parameters expressing incisor inclination to the occlusal plane could be felt to contain a factor resulting from the difficulties in determining the occlusal plane, the inter-incisal angle showed slightly higher variants, obviously due to uncertainty creating incisor axes.

**Table 5.** Results of the two stage non-paired t-test in the group of young patients

| PARAMETER | $t_0$ | $t_1$ | $t_2$ |
|---|---|---|---|
| A-n-b | | | |
| Mean | 5.25 | 4.82 | 3.71 |
| s.d. | 1.65 | 1.38 | 1.74 |
| | t = 0.808 n.s. | | |
| | | t = 2.011* | |
| | t = 2.587** | | |
| MAXILLARY ILS/OP | | | |
| OMean | 70.53 | 59.12 | 61.65 |
| s.d. | 9.55 | 4.61 | 6.55 |
| | t = 4.304 | | |
| | | t = 1.263n.s. | |
| | t = 3.068** | | |
| MANDIBULAR ILI/OP | | | |
| Mean | 67.47 | 62.24 | 62.71 |
| s.d. | 8.21 | 6.49 | 5.75 |
| | t = 2.001n.s. | | |
| | | t = 0.217n.s. | |
| | t = 1.902n.s. | | |
| Inter-incisal angle | | | |
| Mean | 136.53 | 122.12 | 123.71 |
| s.d. | 16.63 | 7.64 | 5.28 |
| | t = 3.149* | | |
| | | t = 0.684n.s. | |
| | t = 2.939** | | |
| ii to A-pg | | | |
| Mean | -1.41 | 0.71 | 2.88 |
| s.d. | 2.77 | 3.29 | 1.53 |
| | t = -1.972n.s. | | |
| | | t = 2.402* | |
| | t = -5.434*** | | |

**Table 6.** Results of the two stage non-paired t-test in the group of mature patients

| PARAMETER | $t_0$ | $t_1$ | $t_2$ |
|---|---|---|---|
| A-n-b | | | |
| Mean | 5.44 | 4.83 | 4.08 |
| s.d. | 1.62 | 1.91 | 1.98 |
| | t = 0.807n.s. | | |
| | | t = 0.905n.s. | |
| | t = 1.764n.s. | | |
| MAXILLARY ILS/OP | | | |
| Mean | 66.00 | 59.33 | 61.17 |
| s.d. | 9.19 | 7.25 | 4.95 |
| | t = 1.889n.s. | | |
| | | t = 0.693n.s. | |
| | t = 1.536n.s. | | |
| MANDIBULAR ILI/OP | | | |
| Mean | 66.92 | 64.50 | 65.00 |
| s.d. | 7.23 | 4.46 | 5.34 |
| | t = 0.944n.s. | | |
| | | t = 0.238n.s. | |
| | t = 0.707n.s. | | |
| Inter-incisal angle | | | |
| Mean | 133.33 | 123.92 | 127.17 |
| s.d. | 15.72 | 10.32 | 7.75 |
| | t = 1.661n.s. | | |
| | | t = 0.835n.s. | |
| | t = 1.167n.s. | | |
| ii to A-pg | | | |
| Mean | -0.58 | 0.50 | 2.08 |
| s.d. | 2.18 | 2.25 | 2.18 |
| | t = -1.146n.s. | | |
| | | t = 1.675n.s. | |
| | t = 2.872n.s. | | |

In general it can be stated that the variation due to measurement and illustrated in the double determination tests, was relatively low compared with the inter-group variation due to treatment.

In the younger group it will be noticed that the ANB angle describing sagittal skeletal relationship decreased in the second stage of treatment ($t_1$ to $t_2$) (jumping stage) from an average of 4.82° to an average of 3.71°, t = 2.011, $p<0.05$. A similar reduction was noted over the entire period of treatment ($t_0$ to $t_2$), from 5.25° to 3.71°, t=2.587, $p<0.01$. A similar change, though to a lesser degree was observed in the more mature group with the ANB value reducing, to a lesser, statistically non-significant degree, 5.44° at $t_0$ to 4.08° after treatment ($t_3$), (t= 1.764, n.s.). The change brought about in the period $t_1$ to $t_2$ was also less than the change in the same period for the younger group and statistically non-significant The inclination of maxillary incisors to the occlusal plane in the younger group was reduced from 70.53° to 59.12° in the first stage of treatment ($t_0$ to $t_1$), t=4.304, $p<0.001$, (implying a levelling-induced proclination) but uprighted slightly to 61.65° in stage $t_2$ (retraction) the overall change from $t_0$ to $t_3$ being a significant protrusion from 70.53° to 61.65° (t = 3.068, $p<0.01$). In the mature group, the degree of maxillary incisor retroclination was less, though the level of proclination of the maxillary incisors was greater in the younger group at the onset of treatment. Despite this variation, the incisors for the older group ended at the same inclination to the nasal plane as for the younger group.

Concerning the position and inclination of the mandibular incisors, only small angular changes were recorded in each of the two stages investigated, though the position of the mandibular incisor edge to A-pg line became slightly more prominent in connection with the alignment stage, ("young patients" (t= 1.972, n.s.), but became significantly protruded from $t_1$ to $t_2$, t= 2.402, $p<0.05$, the overall incisal protrusion from $t_0$ to $t_2$ being t= 5.434, $p<0.001$. In the case of the "mature" patients, small angular changes in the inclination of the incisors and the relationship of the lower incisors to the A-pg line underwent very small non-significant changes in the "mature" group.

No breakages of the jumping devices during treatment were noted.

### *Treatment of Class II div 1 malocclusion in two patients of differing stages of maturation*

The following cases are included to show the clinical effect of the appliance and are chosen to represent two different clinical situations, the first being a 13year old female, where a certain amount of natural growth can be expected and the second a 19 year old male, where the majority of skeletal growth will have already taken place.

### *Patient I.S. ("young" patient)*

A 13 year 3 month old female, DS3 $M2^{12}$ with a distal molar relationship, increased overjet and dental irregularity in both arches, though particularly involving crowding in the maxillary arch. The patient and occlusion are seen in Fig. 10 and the results of the short cephalometric analysis at the initial stage in Table 7, from which it can be seen that the skeletal jaw relationship, prior to orthodontic treatment ($t_0$), is enlarged sagittaly (ANB=6.0°), with a relatively normal maxillary incisor relationship to the occlusal plane (ILs to OP=61.0°), though with a slight retrusion of the mandibular incisors (Ili/OP= 68.0°). The inter-incisor angle was decreased to an angle of 126.0°.

**Table 7.** Patient I.S. cephalometric values prior to treatment

| | |
|---|---|
| SAGITTAL JAW REL. | |
| A-n-B | 6.0° |
| INCISAL INCLINATION to OP | |
| Maxillary Ils/OP | 61.0° |
| Mandibular Ili/OP | 68.0° |
| Inter-incisal angle | 126.0° |
| INCISAL RELATIONSHIP | |
| ii to A-pg | -2.0 mm |

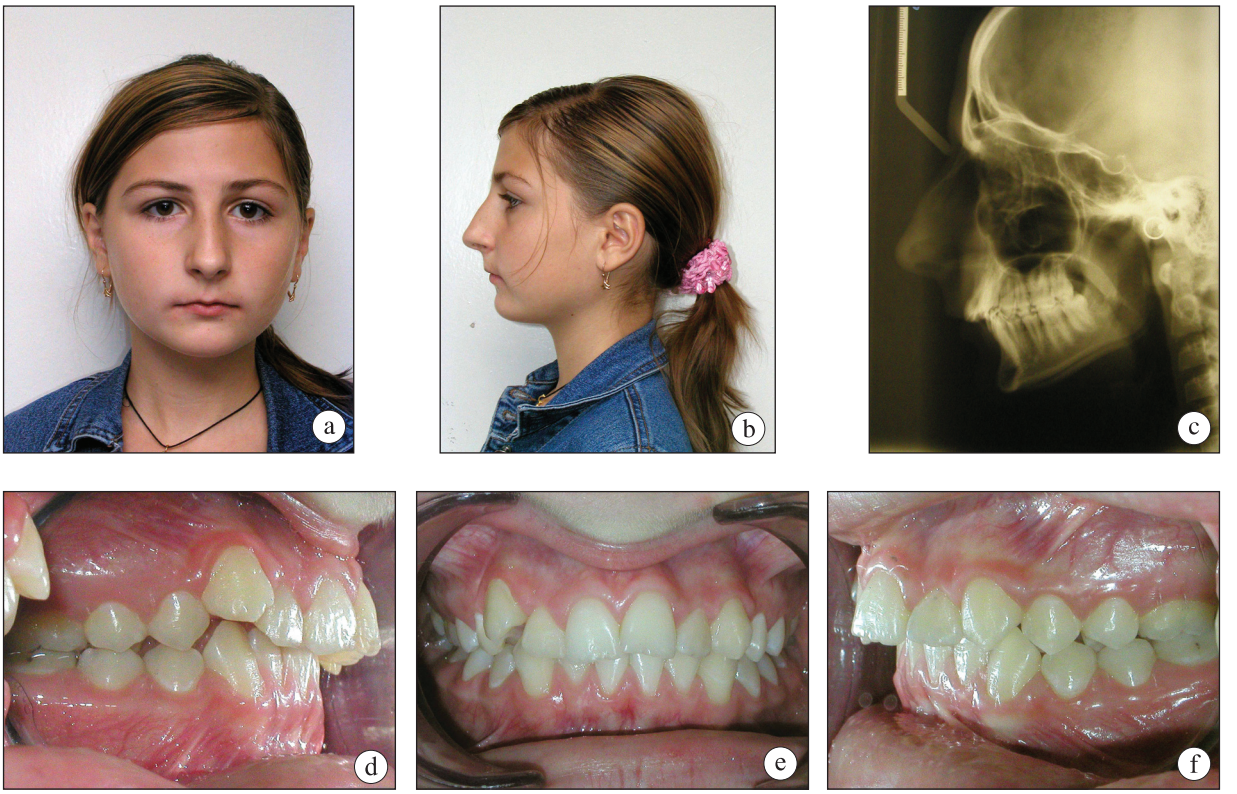

***Fig. 10 a-f.*** *Patient I.S. prior to treatment ($t_0$).*

***Fig. 11 a-c.*** *Patient I.S. after alignment ($t_1$).*

***Fig. 12 a-c.*** *Patient I.S. during treatment with Flex Developer®.*

**The aim of treatment** was to normalize the molar relationship and reduce the overjet achieving good incisor contact.

**The treatment plan** was primarily to align both arches using fixed appliance therapy and to normalize the sagittal relationships using a Flex Developer® jumping appliance. The situation after alignment is shown in Fig. 11 and in the second phase of treatment with the Flex Developer® in place, promoting a normalization of the sagittal relationship in Fig. 12.

After approximately 6 months of the treatment

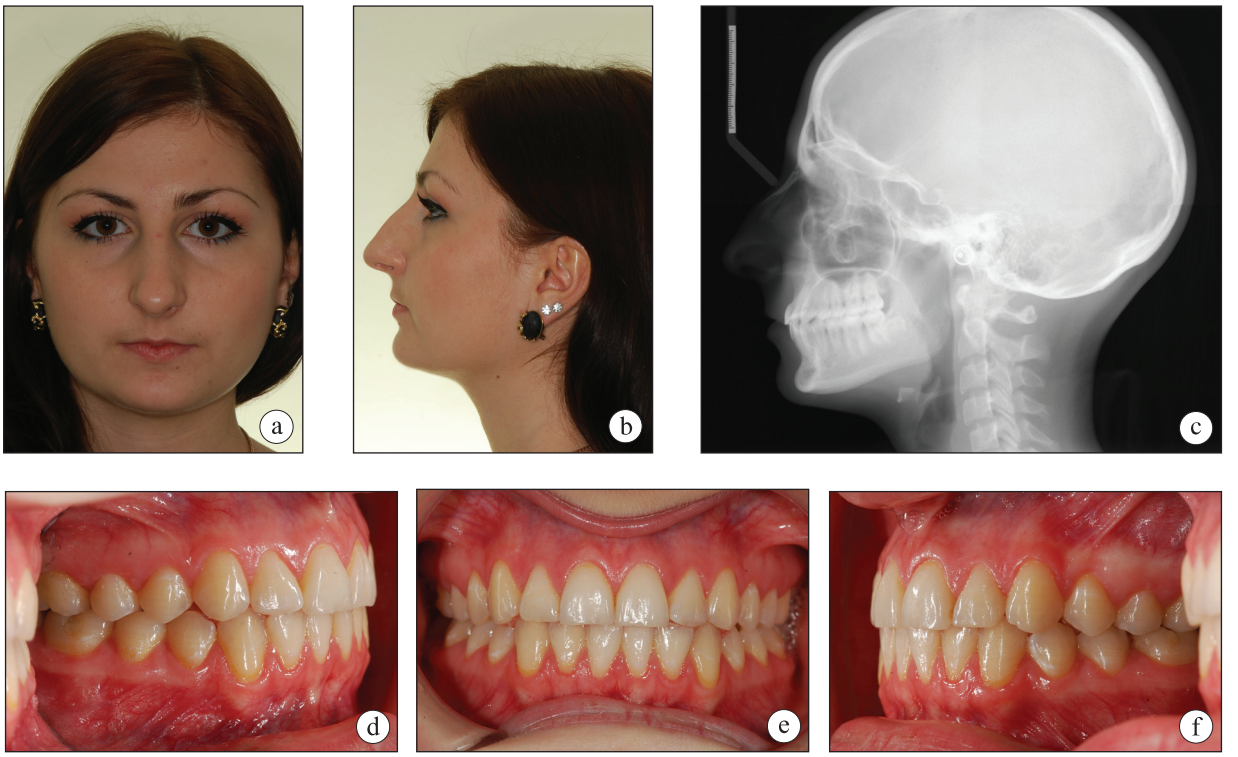


***Fig. 13 a-f.*** *Patient I.S. end of treatment ($t_2$).*

with the jumping device the therapy was finished using a standard edgewise appliance, the results being shown in Fig. 13.

**The morphological changes** arising from growth and treatment expressed cephalometrically can be seen in Table 8. It can be seen that during the period of treatment the sagittal jaw relationship (ANB) reduced, not only in the period with the jumping treatment ($t_1$-$t_2$), but also during the alignment phase ($t_0$-$t_1$).

The most significant changes recorded have been related to the ANB value which reduced

**Table 8.** Patient I.S. cephalometric values in all three stages of treatment

| | To | T1 | T2 |
|---|---|---|---|
| SAGITTAL JAW REL. | | | |
| A-n-B | 6.0º | 5.0º | 3.0º |
| INCISAL INCLINATION to OP | | | |
| Maxillary IIs/OP | 61.0º | 52.0º | 53.0º |
| Mandibular Ili/OP | 68.0º | 60.0º | 70.0º |
| Inter-incisal angle | 126.0º | 111.0º | 123.0º |
| INCISAL RELATIONSHIP | | | |
| ii to A-pg | -2.0 mm | 2.0 mm | 2.0 mm |

from 6.0° prior to treatment, through 5.0° after the levelling stage of the treatment, to 3.0° subsequent to" jumping" and final treatment.

The maxillary incisor proclination increased during the levelling stage ($t_0$-$t_1$) and remained stable during the jumping and finalizing phase ($t_1$-$t_2$). The mandibular incisor inclination to the occlusal plane decreased during the alignment phase ($t_0$-$t_1$), but returned to virtually pre-treatment levels after the jumping and finalizing phase ($t_1$-$t_2$). While the alignment decreased the inter-incisal angle during the alignment phase ($t_0$-$t_1$), the level returned to the pre-treatment value during the jumping and finalizing phase ($t_1$-$t_2$). The sagittal position of the incisal edge of the mandibular incisor was protruded in all a total of 4° during the entire treatment and ended 2.0 mm anterior to the A-pg line, which must be considered acceptable.

### *Patient R.F. ("mature" patient)*

A 19 year 10 month old male presented for treatment for a complex malocclusion involving a distal molar relationship, severe narrowing of the maxillary arch with a resulting loss of space in both arches. The patient and occlusion are shown in Fig. 14 and the initial cephalometric values in Table 9.

**The aim of treatment** was to align both arches simultaneously with the creation of space for alignment of the maxillary arch partly followed normalization of the sagittal molar and incisal relationships and achievement of ideal occlusal relationships in all three planes.

**The treatment plan** was to expand the maxillary arch by means of rapid maxillary expansion after which both arches should be aligned and normalization of the sagittal relationships would be subsequently achieved by means of a mandibular "jumping" device based on fixed appliances used in both arches.

Fig. 15 shows the expansion device (splint borne hyrax type), Fig. 16 alignment of both arches with the "Jumping devices" in place in order to normalize the molar relationship. Fig. 17 illustrates the situation at the end of treatment.

The cephalometrics description of the skeletal and dental morphology is presented in the final cephalometrics in Table 10.

It was recognized from the onset that as a result of the age of patient R.F., skeletal change was relatively unlikely and only dento-alveolar change could therefore be expected. Fig. 17 shows the success of the principles employed. The results of the comparative cephalometric analysis based on the three stages employed indicate virtually no improvement in the skeletal sagittal relationship

**Table 9.** Patient R.F. ceph values prior to treatment

| | |
|---|---|
| SAGITTAL JAW REL. | |
| A-n-B | 4.0º |
| INCISAL INCLINATION to OP | |
| Maxillary Ils/OP | 71.0º |
| Mandibular Ili/OP | 70.0º |
| Inter-incisal angle | 143.0º |
| INCISAL RELATIONSHIP | |
| Horizontal overjet | 3.8º |
| Vertical overbite | 4.5º |
| ii to A-pg | -1.0 mm |

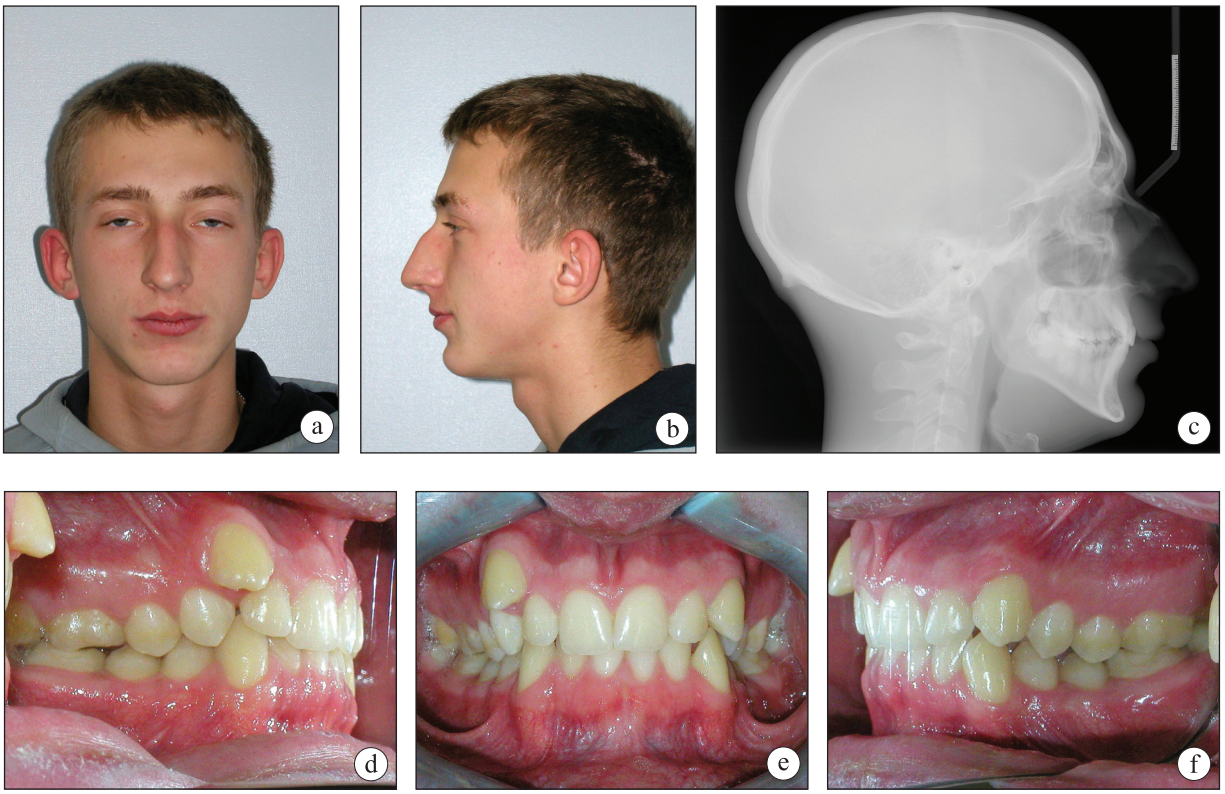

***Fig. 14 a-f.*** *Patient R.F. prior to treatment ($t_0$).*

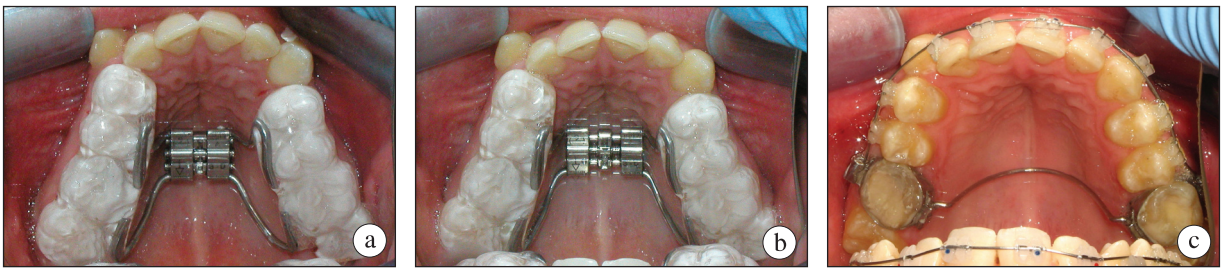

***Fig. 15 a-c.*** *Patient R.F. before and after rapid maxillary expansion.*

***Fig. 16 a-c.*** *Patient R.F. after alignment with Flex developer® in place.*

(ANB), occurring in the "jumping" stage. The clear change in the occlusion was due to proclination of the previously retroclined mandibular incisors at the same time as the levelling of the maxillary arch was accompanied by a protrusion of the maxillary incisors. In this way space was gained making it

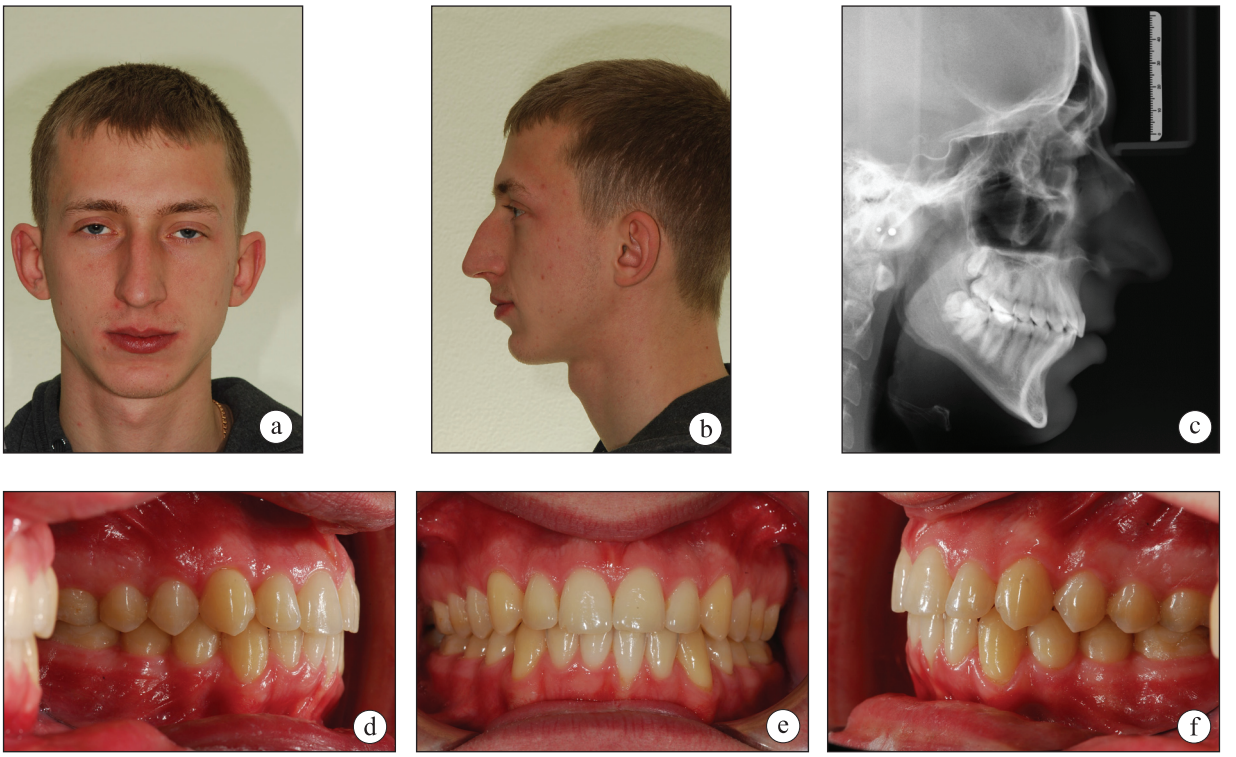


***Fig. 17 a-f.*** *Patient R.F. end of treatment ($t_3$).*

**Table 10.** Patient R.F. ceph values in all three stages of treatment

| SAGITTAL JAW REL. | $T_0$ | $T_1$ | $T_2$ |
|---|---|---|---|
| A-n-B | 4.5° | 5.0° | 4.0° |
| INCISAL INCLINATION to OP | | | |
| Maxillary IIs/OP | 71.0° | 49.0° | 57.0° |
| Mandibular Ili/OP | 70.0° | 56.0° | 63.0° |
| Inter-incisal angle | 143.0° | 105.0° | 120.0° |
| INCISAL RELATIONSHIP | | | |
| Horizontal overjet | 3.8° | 5.5° | 3.0° |
| Vertical overbite | 4.5° | -1.0° | 2.0° |
| ii to A-pg | -1.0 mm | 3.0 mm | 3.0 mm |

possible to align the maxillary canine[13] which had previously been completely outside the arch. The result of the jumping effect ($t_1$-$t_2$) was a clear retraction of the maxillary incisors (often described as the "headgear effect")[13] reducing the incisal protrusion necessary to gain space for the canine.

## Discussion

The use of jumping devices in the treatment of Class II malocclusion is now well accepted, being based on the original theories and clinical principles of *Emil Herbst*.[1] With the basic principles in mind many alternative constructions have been suggested and marketed, basically in an attempt to simplify the construction of the appliances and/or to reduce the cost. Comparison of the effects of the various appliances are relatively rare in the literature, basically since the effect of the Herbst appliance has been so thoroughly reported.[14-16] Several reports suggest that the effects of the later designed jumping devices are very similar to those achieved with the Herbst appliance. The aim of the development of the "Sagittal Developer® was basically a practical one hoping to reduce breakage of the appliance during treatment since many years of experiences made by the authors recognize this as a problem with both Herbst and other jumping devices. The results of the present study indicate clearly that the physical characteristics of the nylon rod on which the developer is based offer greater resistance to breakage.

In an excellent review of the success of orthopaedic treatment *Aelbers* and *Dermaut*[17] suggest that true orthopaedic correction of sagittal skeletal discrepancies is rare, though suggest that the Herbst appliance could be considered an exception. It is felt that the changes seen with the Flex Developer® are very similar to those reported with the Herbst appliance, i.e. changes resulting from a combination of skeletal and dento alveolar changes[2] including the so-called "headgear effect".[13] Such a change in the sagittal jaw relationship over a short period of time would be unlikely to be the result of growth alone and must be ascribed in part the effect of the "jumping" treatment.

Recognizing the limits of the patient material which forms the basis for this study, in particular the limited size, population bias as well as some degree of methodological error it would be correct to overstress the effect of skeletal maturity based on the changes observed. It is though interesting to note that a greater reduction in the ANB angle was recorded in the younger adolescent group, where growth intensity was probably greater. This was also observed in the case of the single patient described. While this could be interpreted as "corroborating evidence" it could be interpreted such that a greater skeletal effect of the jumping device could be expected in the presence of active growth and indicate the optimal time for treatment with such an appliance could be during a period of active growth. This finding would be in agreement with other studies concerning the effect of bite jumping appliance on more mature patients.[18]

Several other reports have suggested that unwanted proclination of the mandibular incisors could be the result of the large anteriorly directed forces arising from the jumping device on the relatively small anchorage offered by the mandibular incisors. In this respect it must be remembered that the results shown in the second period, while reflecting the clinical reality, illustrate the effect of both the jumping device, as well as the fixed orthodontic appliance. The present report confirms the effect of the forces on the mandibular incisors though it is felt that the effect on the final position of these teeth is not adverse.

The creation of the Flex Developer® was based on the desire to produce a stable, non-destructible, jumping device. Experience with the 29 patients described in this study shows that under normal usage, this type of appliance can resist the forces employed with virtually no breakage. Results of the present study, not least based on the results observed clinically underline that the flex developer represents a suitable adjunct to treatment of skeletal Class II malocclusion.

## Conclusion

The aim of the project, namely to develop an adjustable, virtually indestructible jumping device for the treatment of skeletal Class II malocclusion appears to have been achieved with the creation of the Flex Developer®. The pilot study reported suggests that the clinical effect of the appliance is similar to the Herbst appliance reported elsewhere in more extensive studies. The correction of the malocclusion was a combination of skeletal and dento-alveolar effects and appeared to be more skeletal of nature, when the appliance was used in growing patients.

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